

“Observations on the Physiology of the Cerebral Cortex of the Anthropoid Apes.” By A. S. F. GRÜNBAUM, M.D., F.R.C.P., and C. S. SHERRINGTON, M.A., M.D., F.R.S. Received May 25, —Read June 11, 1903.

(From the Physiological Laboratory, University of Liverpool.)

Since presenting our former note on this subject, we have obtained some further observations, though the number is still less than we should wish, owing to the rarity and expense of the material. Our further observations have been upon five chimpanzees of the commoner variety, and upon one more orang.

The statements given in our former communication have been confirmed in all respects by our observations obtained since then. We can, further, now make the following statements in addition :—

The whole of the surface of the “island of Reil” has proved “inexcitable” under faradisation with currents even considerably more intense than those sufficing to excite muscular movements when applied to the pre-central convolution. This is noteworthy because the large extent of the insula is a character distinguishing the brain of the anthropoid apes from that of the lower apes, and bringing it nearer toward the human type.

Faradisation of the cortex of the inferior frontal convolution in either hemisphere has failed in our hands so far to elicit movements of any satisfactory degree of regularity or constancy; and this even under use of currents much stronger than those which suffice when applied to the “motor” cortex proper. The movements for which, in particular, careful search was made, were those connected with vocalisation. From the posterior region of the convolution, at scattered points, and without constancy even at them, strong faradisation occasionally seemed to induce movements in the larynx, distinguishable from the rhythmic of respiratory origin. Judging from such evidence as we altogether obtained, we conclude that either (1) no Broca “speech centre,” at all distantly foreshadowing the human, exists in these anthropoid brains, or (2) that direct faradisation of the Broca speech cortex is inefficient itself to evoke vocalisation. These two inferences, are, of course, not mutually exclusive, and both the suppositions may be correct.

Repeated observations on excitation of the cortex of the pre-central convolution confirm an opinion we had formed at the time of our former communication, and indicated in the diagram then furnished, but not verbally expressed. This is to the effect that the anterior limit of the “motor” field is not of sharp, abrupt character, but fades off forward somewhat gradually. This edge extends further forward under “*Bahnung*.” Under general conditions producing lowered

excitability of the cortex it retires backward in the direction of the central fissure.

In a similar manner the boundary of the area for any particular movement, may by "*Bahnung*" be extended beyond its average limit. The special form of movement provoked from a given spot of cortex is thus influenced by the particular forms of movement excited from neighbouring points just antecedently.

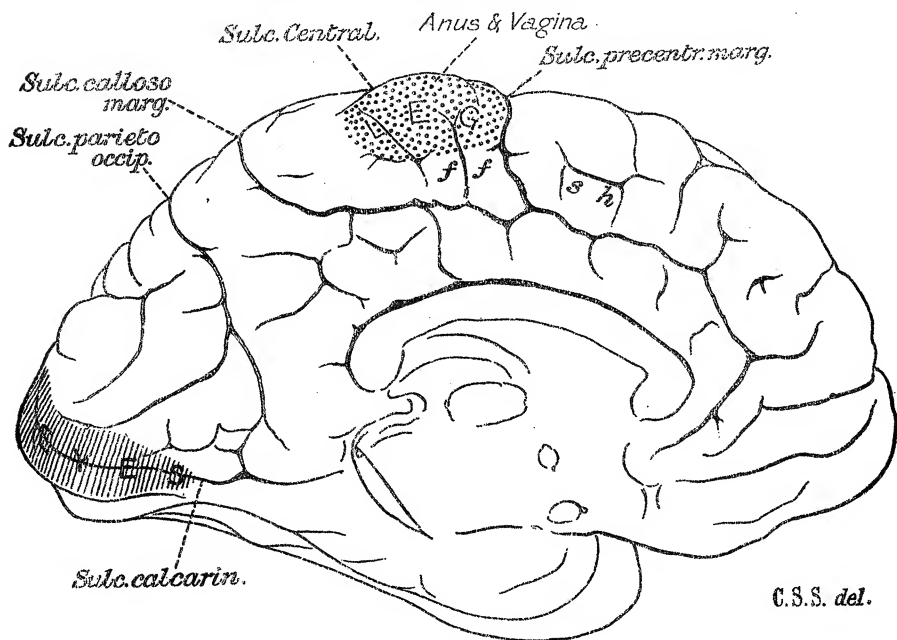
Among movements elicited from the cortex of the "facial" region, we have in two instances seen protrusion of the tongue, succeeded by forcible closure of the jaws following rapidly before retraction had withdrawn the tongue behind the arcades of the teeth; so that in these instances the tongue was caught by the closure of the teeth. This sequence of movements presents interest, as evidencing that a sequence of movement evoked by excitation of the cortex may exhibit in some respects faulty co-ordination. The movement, is also of interest as a result of direct cortical excitation which harmonises with the biting of the tongue in epileptic seizures.

Ablation of the facial area of the "motor" region was performed in one individual. A crossed hemiparesis ensued in the lips, cheek, tongue, nasal fold, and lower eyelid (very slight), but not in the upper lid, eyebrow, or frontal region.

As to the recovery of movement that occurs in a limb rendered paretic by ablation of its cortical area in the "motor" region, we find the following points: If all the area, which when faradised evokes movements of fingers, thumb, and wrist primarily, and not as a later sequel to movements starting elsewhere, be excised, the paretic condition of the hand which ensues is severe, but rapidly diminishes. In a few weeks the hand is again very fairly and freely used. If, then, the whole of the corresponding area in the opposite hemisphere is removed, a similar paresis similarly ensues in the other hand, and runs a similar course; but this second lesion does not produce, so far as we have been able to discover, the slightest recrudescence of the paresis already recovered from in the first hand. On the contrary, the first hand is almost at once employed more freely and successfully than prior to the second operation, presumably because of greater inducement to use it during the disability existing in the second hand. If, then, later, after the second hand has regained its use, the remaining part of the arm area first operated upon be ablated, this causes no obvious recrudescence of paresis either in the first hand or in the second hand. It causes severe paresis at shoulder, and to some extent at elbow, on the side crossed to the lesion, but this, again, is in great part of temporary character, and is largely recovered from. In accord with the absence of recrudescence of the hand paresis on ablating in the third operation the remaining intact part of the arm area, we found that faradisation of that part (elbow and shoulder) provoked, as

usual, movements of elbow and shoulder, but not of hand itself, or only of hand late in a general arm movement, and that very rarely. In short, neither the ablation or the excitation methods gave any evidence that the remaining part of the arm area had taken on the functions of the ablated hand area. The recovery of hand movement seems, therefore, not due to either the adjacent cortex of the same hemisphere, or to the corresponding hand area of the cortex of the opposite hemisphere, taking on the functions of the ablated cortical hand area.

Faradisation of the cortex of the post-central convolution, though



not like the pre-central itself eliciting movement, when employed at certain places facilitates the elicitation of movement by faradisation at certain points at about the same horizontal level in the pre-central convolution. In other words, from certain parts of the post-central convolution, a facilitating influence (*Bahnung*) can be exerted upon somewhat adjacent parts of the pre-central convolution.

Removal of the adjacent levels of the pre-central convolution does not render the post-central convolution "excitable;" that is to say, destruction of the pre-central convolution does not make it the more possible to obtain movements under faradisation from the post-central convolution.

The motor cortex of the infant chimpanzee, a few weeks old, is

readily excitable by faradisation. Its reactions do not appear to differ obviously in this respect from those obtainable from the adult. The movements it yields are not choreiform in character.

The spinal degeneration ensuing upon ablation of the arm area of the motor cortex of the chimpanzee, although it sometimes reveals a large uncrossed ventral pyramidal tract (direct Py. Tr.), does not do so in every case. Even after bilateral arm area lesions, the ventral pyramidal degeneration in the spinal cord may be very slight. The anthropoid cord resembles the human, therefore, not only in the possession of this tract, but in exhibiting in regard to it a remarkable degree of individual variation of development as Flechsig showed to be the case in man.

The expenses of this research have been in part defrayed by a grant kindly allowed by the Scientific Grants Committee of the British Medical Association.

DESCRIPTION OF FIGURE.

Brain of a chimpanzee (*Troglodytes niger*). Left hemisphere; mesial surface. The extent of the "motor" area on the free surface of the hemisphere is indicated by the black stippling. On the stippled area "LEG," indicates that movements of the lower limb are directly represented in all the regions of the "motor" area visible from this aspect. Such mutual overlapping of the minuter sub-divisions exists in this area that the diagram does not attempt to exhibit them. The pointing line from "Anus, etc.," indicates broadly the position of the area whence perineal movements are primarily elicitable.

Sulc. Central. = central fissure. *Sulc. calcarin.* = calcarine fissure. *Sulc. parieto occip.* = parieto-occipital fissure. *Sulc. calloso marg.* = calloso-marginal fissure. *Sulc. precentr. marg.* = pre-central marginal fissure.

The single italic letters mark spots whence, occasionally and irregularly, movements of the foot and leg (*ff*), of the shoulder and chest (*s*), and of the thumb and fingers (*h*) have been evoked by strong faradisation. Similarly the shaded area marked "EYES" indicates a field of free surface of cortex which under faradisation yields conjugate movements of the eyeballs. The conditions of obtainment of these reactions separates them from those characterising the "motor" area.

